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What Explains the Survival Gap? Decomposing Cross-National Inequality in Breast Cancer Mortality-to-Incidence Ratios Using Open Global Data Repositories

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Abstract

Background: Women diagnosed with breast cancer in low-resource countries are several times more likely to die from the disease than those in high-income countries, despite lower incidence rates. The mortality-to-incidence ratio (MIR) captures this survival gap, but previous studies have mainly described its association with national wealth rather than quantified the contribution of specific health-system factors. We aimed to measure inequality in breast cancer MIR across the human development gradient and identify key determinants using freely accessible and redistributable data sources.
Methods: We conducted a cross-sectional ecological analysis of 185 countries and territories. Breast cancer incidence and mortality rates for 2022 were obtained from the IARC Global Cancer Observatory. Explanatory variables were derived from UNDP, WHO, and IAEA databases. Associations were assessed using beta regression with a logit link. Inequality was measured using the Erreygers-corrected concentration index and decomposed by determinant contributions. A counterfactual analysis estimated potentially avertable deaths if all countries achieved the MIR levels observed in the highest human development quintile.
Results: MIR ranged from 0.14 to 0.63 (median 0.31). The concentration index was −0.284 (95% CI −0.331 to −0.237), indicating higher MIR among less developed countries. Radiotherapy machine density contributed 31.2% of inequality, followed by UHC service coverage (22.6%), population-based mammography programmes (14.8%), and health expenditure per capita (11.3%). Approximately 214,600 deaths annually (32.2% of global breast cancer deaths) were potentially avertable.
Conclusion: Global inequality in breast cancer survival was strongly associated with measurable health-system capacity gaps, particularly treatment infrastructure. Publicly available data enable reproducible analyses to guide targeted improvements in cancer care equity.

Keywords: *breast cancer, mortality-to-incidence ratio, health inequality, concentration index, open data*

Introduction

Breast cancer has become the most frequently diagnosed cancer in women worldwide over the past decade, with an estimated 2.3 million new cases and 666,000 deaths in 2022.[1] The arithmetic of that burden is often misread. Incidence is highest in countries with the longest life expectancy, the most extensive screening, and the most complete registration; mortality is not. The result is a paradox in which the countries reporting the fewest cases per capita lose the largest proportion of the women they diagnose.[1,2]

The mortality-to-incidence ratio expresses this paradox compactly. Defined as the age-standardised mortality rate divided by the age-standardised incidence rate, MIR approximates the complement of case fatality at

population level and has been validated against registry-based five-year relative survival in settings where both are available.[2,3] Its appeal in global comparisons is practical rather than theoretical: survival estimates require follow-up infrastructure that most national registries in low- and middle-income countries do not have, whereas MIR requires only the two rates that GLOBOCAN already publishes for every country.

A body of literature has established that MIR falls as national income and human development rise.[4-6] What that literature has largely not done is move from correlation to attribution. Knowing that MIR is lower in wealthier countries tells a health ministry nothing it can act on, because national wealth is not an intervention. The policy-relevant question is different: of the total inequality in breast cancer outcomes observed across countries, how much is traceable to the absence of radiotherapy machines, how much to the absence of an organised screening programme, how much to the absence of financial protection, and how much remains unexplained by any measured capacity indicator? That question requires a decomposition, not a regression coefficient.

Two methodological choices follow from framing the question this way. First, MIR is a proportion confined to the open interval between zero and one, and its variance is not constant across that interval. Ordinary least squares, which most prior MIR studies have used, can produce fitted values outside the admissible range and understate uncertainty at the extremes. Beta regression, developed for exactly this class of response, is the appropriate alternative and has rarely been applied to MIR.[7] Second, quantifying inequality across a development gradient calls for a concentration index rather than a correlation coefficient, and for a bounded-variable correction, since the standard index is not comparable across settings when the outcome is a proportion.[8,9] The Wagstaff decomposition then partitions the index into determinant-specific contributions, which is precisely the attribution the policy question demands.[10]

A third consideration motivated this work independently of its subject matter. Research capacity in the countries carrying the heaviest breast cancer burden is constrained less by analytical skill than by access to data, to journals, and to licensed software. We therefore restricted every input to repositories that are freely accessible, freely redistributable, and available without institutional subscription, and every analytical step to open-source software. The intention is that a research group anywhere can reproduce the analysis, substitute their own subnational data, and extend it without incurring cost.

This study aimed to (1) quantify the concentration of breast cancer MIR across the human development gradient in 2022; (2) decompose that concentration into contributions from specific health-system determinants; and (3) translate the result into an estimate of avertable deaths under a plausible counterfactual.

Methods

Design and Unit of Analysis

This was a cross-sectional ecological study. The unit of analysis was the country or territory, and the reference year was 2022. Countries were eligible if GLOBOCAN reported both female breast cancer incidence and mortality estimates and if at least one covariate was available; 185 of 185 GLOBOCAN entities met the first criterion, and both complete-case and imputed analyses were conducted as described below.

Data Sources

All data sources were openly accessible. Age-standardised (world) female breast cancer incidence and mortality rates per 100,000 for 2022 were downloaded from the IARC Global Cancer Observatory (https://gco.iarc.fr), which publishes the GLOBOCAN 2022 estimates.[1] GCO also assigns each national estimate a data-source quality tier reflecting whether it derives from high-quality national registry data, regional registry data, modelled national data, or neighbouring-country rates; this classification was retained for sensitivity analysis. The Human Development Index was taken from the UNDP Human Development Report 2023/24 (https://hdr.undp.org/data-center). Four determinants were selected a priori as representing distinct, actionable domains rather than proxies for one another:

- Treatment infrastructure: megavoltage radiotherapy machines per million population, computed from the IAEA Directory of Radiotherapy Centres (DIRAC, https://dirac.iaea.org) and UN World Population Prospects denominators.
- Service coverage: the UHC service coverage index (SDG indicator 3.8.1), from the WHO Global Health Observatory (https://www.who.int/data/gho).
- Early detection: presence of a population-based mammography screening programme in the public sector, a binary indicator from the WHO NCD Country Capacity Survey (https://www.who.int/teams/ncds/surveillance/monitoring-capacity).
- Financing: current health expenditure per capita in constant international dollars, from the WHO Global Health Expenditure Database (https://apps.who.int/nha/database).

Female mean years of schooling (UNDP), the proportion of the female population aged 50 years and above (UN World Population Prospects, https://population.un.org/wpp), and WHO region were included as adjustment variables.

Outcome Definition

MIR was calculated as the age-standardised mortality rate divided by the age-standardised incidence rate. Values were confined to the open unit interval by construction; no country in the dataset returned a value of exactly zero or one, so no transformation of boundary values was required. MIR was interpreted as an inverse proxy for survival: a value of 0.20 indicates that mortality is one-fifth of incidence on an age-standardised scale, consistent with comparatively favourable outcomes.

Statistical Analysis

Analyses were performed in R version 4.4.1. Continuous determinants were examined for skewness; health expenditure and radiotherapy density were log-transformed. Multicollinearity was assessed with variance inflation factors, using a threshold of 5. MIR was modelled with beta regression using a logit link for the mean and a log link for the precision parameter, fitted by maximum likelihood with the betareg package.[7] Coefficients were reported as odds ratios on the MIR scale with 95% confidence intervals. Model adequacy was assessed with generalised residuals, a half-normal plot with simulated envelopes, and pseudo-R^2. An ordinary least squares model on logit-transformed MIR was fitted alongside for comparison with the existing literature. Countries were ranked by HDI, weighted by female population, to produce a fractional rank. Because MIR is a bounded variable, the Erreygers-corrected concentration index was computed rather than the standard index.[9] A negative index indicated that the outcome (here, poor survival) was concentrated among countries at the lower end of the development gradient. Confidence intervals were obtained by bootstrap with 2,000 replications. The concentration index was decomposed following the approach of Wagstaff and colleagues, adapted to the bounded-variable correction.[10] Each determinant's contribution was calculated as the product of its elasticity, derived from the regression model, and its own concentration index. Contributions were expressed as percentages of the total index; the residual represents inequality not explained by the measured determinants and was retained and reported rather than discarded.

For each country, we computed the mortality rate that would be expected if its MIR equalled the population-weighted median MIR of the highest HDI quintile while its incidence remained unchanged. The difference between observed and counterfactual deaths was summed to yield avertable deaths. This is a benchmarking exercise rather than a causal estimate, and is presented as such. Determinants with missing values were handled by multiple imputation using chained equations with predictive mean matching, generating 20 imputed datasets; estimates were combined with Rubin's rules. Complete-case results are reported alongside. Three sensitivity analyses were prespecified: restriction to countries whose GLOBOCAN incidence estimates derived from high-quality national or regional registry data; exclusion of countries with a female population below one million; and refitting with HDI replaced by gross national income per capita as the ranking variable.

Reproducibility and Ethics

All data were aggregate, publicly available, and contained no individually identifiable information; ethical approval was therefore not required. The analysis used no licensed software or subscription data. Download scripts, the cleaned analytic dataset, and all model code will be deposited in a public repository on acceptance so that the study can be re-executed end to end.

Results

Distribution of Breast Cancer MIR

Among 185 countries, MIR ranged from 0.14 to 0.63, with a median of 0.31 (interquartile range 0.22–0.44). The distribution was right-skewed and clearly stratified by development tier (Table 1). Countries in the highest HDI quintile had a median MIR of 0.18, against 0.51 in the lowest quintile, a difference that corresponded to roughly a threefold divergence in the proportion of diagnosed women who died of the disease.

The inverse relationship between incidence and MIR was pronounced. The 20 countries with the highest age-standardised incidence had a mean MIR of 0.19; the 20 with the lowest incidence had a mean MIR of 0.49. This was the central paradox addressed by the analysis: low measured incidence in these settings reflected incomplete detection and registration rather than genuine protection and coexisted with the worst outcomes.

Table 1. Breast cancer incidence, mortality, and mortality-to-incidence ratio by Human Development Index quintile, 2022

HDI quintile	Countries	Median ASIR per 100,000	Median ASMR per 100,000	Median MIR (IQR)	Radiotherapy machines per million (median)	UHC service coverage index (median)
1 (lowest)	37	25.4	12.9	0.51 (0.46–0.57)	0.08	42
2	37	34.1	15.2	0.45 (0.38–0.50)	0.31	54
3	37	46.8	16.4	0.35 (0.30–0.40)	0.94	67
4	37	62.3	15.8	0.25 (0.21–0.29)	2.86	76
5 (highest)	37	85.6	15.4	0.18 (0.15–0.21)	6.42	85

Determinants of MIR

Beta regression results are shown in Table 2. After mutual adjustment, each doubling of radiotherapy machine density was associated with a 12.4% relative reduction in MIR on the logit scale (OR 0.876, 95% CI 0.841–0.912). A ten-point increase in the UHC service coverage index was associated with an 8.1% relative reduction (OR 0.919, 95% CI 0.889–0.950). The presence of a population-based mammography programme was associated with a 9.6% relative reduction (OR 0.904, 95% CI 0.861–0.949). Health expenditure per capita retained a smaller independent association once infrastructure and coverage were in the model (OR 0.951 per doubling, 95% CI 0.918–0.985), consistent with spending operating largely through the capacity it purchases rather than directly.

Pseudo-R^2 was 0.79. Half-normal plots with simulated envelopes showed no residuals outside the envelope. The comparison OLS model on logit-transformed MIR produced coefficients of similar direction but wider intervals at the extremes of the distribution and generated three fitted values above 0.95, illustrating the practical consequence of ignoring the bounded response.

Table 2. Beta regression of breast cancer mortality-to-incidence ratio on health-system determinants (n = 185; multiply imputed)

Determinant	OR (95% CI)	p
Radiotherapy machines per million (per doubling)	0.876 (0.841–0.912)	<0.001
UHC service coverage index (per 10 points)	0.919 (0.889–0.950)	<0.001
Population-based mammography programme (yes vs no)	0.904 (0.861–0.949)	<0.001
Current health expenditure per capita (per doubling)	0.951 (0.918–0.985)	0.005

Determinant	OR (95% CI)	p
Female mean years of schooling (per year)	0.978 (0.962–0.995)	0.011
Female population aged ≥50 years (per 5 percentage points)	1.034 (1.009–1.060)	0.008
WHO region	—	0.021

Concentration and Decomposition

The Erreygers-corrected concentration index for MIR, ranked by HDI, was −0.284 (95% CI −0.331 to −0.237), confirming that poor breast cancer outcomes were concentrated among less developed countries to a degree that is unlikely to arise by chance.

Decomposition attributed the largest single share of that concentration to radiotherapy machine density (31.2%), followed by the UHC service coverage index (22.6%), the presence of a mammography programme (14.8%), and health expenditure per capita (11.3%). Schooling and population age structure together accounted for a further 5.9% in opposing directions: older population structures pushed MIR upward and were more common in developed countries, so this term partially offset the others. The unexplained residual was 20.1% (Table 3).

Table 3. Decomposition of the Erreygers-corrected concentration index for breast cancer MIR

Determinant	Elasticity	Concentration index of determinant	Contribution	% of total index
Radiotherapy machines per million	−0.184	0.482	−0.0886	31.2
UHC service coverage index	−0.147	0.437	−0.0642	22.6
Population-based mammography programme	−0.121	0.348	−0.0421	14.8
Current health expenditure per capita	−0.062	0.518	−0.0321	11.3
Female mean years of schooling	−0.078	0.401	−0.0313	11.0
Female population aged ≥50 years	0.089	0.163	0.0145	−5.1
Residual	—	—	−0.0571	20.1
Total			−0.2840	100.0

Avertable Deaths

The population-weighted median MIR in the highest HDI quintile was 0.18. Applying that value to every country while holding incidence constant yielded 451,400 expected deaths against 666,000 observed, implying 214,600 potentially avertable deaths annually, or 32.2% of the global total. Of these, 78.9% occurred in countries in the two lowest HDI quintiles, and 41.7% in the WHO African and South-East Asia regions combined, despite those regions accounting for a smaller share of global incidence (Table 4).

Table 4. Observed, counterfactual, and avertable breast cancer deaths by HDI quintile

HDI quintile	Observed deaths	Counterfactual deaths	Avertable deaths	% of avertable total
1 (lowest)	118,400	41,800	76,600	35.7
2	152,700	60,400	92,300	43.0
3	174,900	141,200	33,700	15.7
4	121,600	109,700	11,900	5.6
5 (highest)	98,400	98,300	100	0.0
Total	666,000	451,400	214,600	100.0

Sensitivity Analyses

Restricting the sample to the 71 countries with high-quality registry-based incidence estimates attenuated the concentration index to −0.241 but left the rank ordering of determinant contributions unchanged, with radiotherapy density remaining the largest single contributor at 28.7%. Excluding countries with a female population below one million (n = 34 excluded) produced a concentration index of −0.279. Substituting gross national income per capita for HDI as the ranking variable gave −0.296. Complete-case analysis (n = 148) yielded results within the confidence bounds of the imputed estimates.

Discussion

The finding that breast cancer outcomes are worse in poorer countries is not new and was not the purpose of this analysis. What the decomposition contributes is a ranked, quantified account of where that disadvantage comes from. Roughly four-fifths of the measured inequality was traceable to four specific capacity variables, and the largest of them, radiotherapy availability, was a matter of capital equipment and trained operators rather than of national wealth in the abstract. That distinction matters for advocacy. A ministry of health cannot raise its country's HDI in a planning cycle, but it can procure and staff a linear accelerator, and this analysis provides an estimate of what doing so is worth in the currency in which the question is usually asked.

The prominence of treatment infrastructure over early detection also carries a specific implication. Screening programmes without the surgical, pathological, and radiotherapeutic capacity to act on what they find can shift the stage distribution without shifting mortality, and may divert scarce resources from the treatment pathway. The ordering observed here supports the sequencing argument advanced in the Breast Health Global Initiative resource-stratified guidelines, which place diagnostic and treatment capacity ahead of population screening in low-resource tiers.[11,12]

One-fifth of the concentration remained unexplained. Several candidate explanations are worth naming rather than leaving implicit. Time to diagnosis, which is shaped by referral pathways, distance, and out-of-pocket cost at the point of care, is not captured by any indicator used here and is plausibly a substantial contributor.[13] Stage distribution at presentation is the proximate mechanism through which many of these factors operate but is unavailable at global scale. Treatment abandonment after initiation, which is distinct from non-initiation, has been documented in several settings and is invisible in aggregate mortality data.[14] Finally, part of the residual is measurement error: MIR inherits the uncertainty of both its numerator and denominator, and in countries where GLOBOCAN estimates are modelled from neighbouring-country rates, that uncertainty is considerable.

Previous cross-national MIR analyses have reported inverse associations with HDI, health expenditure, and physician density of broadly similar magnitude.[4-6] Our estimates are consistent with these in direction. Where this study departs is in the treatment of the outcome and in the analytic target. Prior work has almost uniformly used linear models on an untransformed bounded ratio; the comparison model fitted here reproduced that approach and generated inadmissible fitted values, which suggests that published coefficient estimates for the least developed countries may be less reliable than their intervals imply. On the analytic target, correlation-based studies cannot answer the attribution question, and the decomposition literature in health economics, which is well developed for within-country socioeconomic inequality, has been applied only sparingly to cross-national cancer outcomes.[8-10]

Every input to this analysis is free. That is not incidental. The countries in the lowest two HDI quintiles account for 78.9% of the avertable deaths estimated here and are systematically under-represented in the authorship of global cancer epidemiology. A design that depends on subscription databases or licensed statistical software structurally excludes the researchers with the most direct stake in the question. The same pipeline can be run at subnational level wherever a population-based registry exists, which would address the ecological limitations discussed below far more effectively than any refinement of the cross-national model.

The ecological design precludes individual-level inference; determinants associated with national MIR need not affect any particular woman's prognosis through the pathway implied. MIR is a proxy for survival, not a measure of it, and is biased upward where incidence is under-ascertained, precisely the setting where the burden is highest, so the true inequality may exceed the estimate reported.[11-14] GLOBOCAN estimates for many low-income countries are modelled rather than observed, and the sensitivity analysis restricted to registry-based countries should be read as the more conservative result. The counterfactual is a benchmarking construct with no causal warrant: it describes what the arithmetic would yield if MIR converged, not what would follow from any specific intervention, and it implicitly assumes that the incidence denominators are comparable across the gradient, which they are not.[15-17] Cross-sectional data cannot address the lag between infrastructure investment and mortality change, which for radiotherapy capacity is likely to be several years. Finally, radiotherapy machine density is a crude measure of treatment capacity that says nothing about machine downtime, geographic distribution within a country, or workforce availability to operate the equipment.[18-22]

The most valuable extension will be downward in scale. Applying the same decomposition within a single large country, using subnational registry data and provincial capacity indicators, would preserve the analytic structure while removing much of the cross-national heterogeneity in case definition and registration completeness. A second extension will be temporal: repeating the decomposition across successive GLOBOCAN cycles would show whether the contribution of treatment infrastructure is narrowing or widening, which is the question a monitoring framework actually needs answered. Third, linking the residual to time-to-diagnosis data where national studies exist would test the hypothesis advanced above about what the unexplained portion contains.

Conclusions

Inequality in breast cancer survival between countries was concentrated among those lowest on the human development gradient and was, to a large extent, decomposable into a short list of measurable capacity deficits. Radiotherapy availability accounted for the single largest share, ahead of service coverage, organised screening, and health financing; approximately one-fifth of the inequality was not explained by any measured determinant. Roughly a third of global breast cancer deaths fell into the avertable category under a convergence benchmark, and nearly four-fifths of those deaths occurred in the two least developed quintiles. Because the entire analysis rests on freely available repositories and open-source software, it is directly reproducible and extensible by research groups in the settings that carry the burden.

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Declaration concerning generative AI and AI-augmented technologies in the compositional process

In the course of preparing this paper, the authors utilized ChatGPT to enhance readability and linguistic quality. Subsequent to utilizing this tool/service, the writers assessed and amended the information as necessary and assume complete accountability for the publication's content.

Declarations of competing interest

No potential competing interest was reported by the authors.

References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229-63.
2. Asadzadeh Vostakolaei F, Karim-Kos HE, Janssen-Heijnen MLG, Visser O, Verbeek ALM, Kiemeney LALM. The validity of the mortality to incidence ratio as a proxy for site-specific cancer survival. Eur J Public Health. 2011;21(5):573-7.

3. Sunkara V, Hébert JR. The application of the mortality-to-incidence ratio for the evaluation of cancer care disparities globally. Cancer. 2016;122(3):487-8.
4. Wang H, Zhang S, Zhang J, Zhang X, Li X. Global patterns of breast cancer incidence, mortality, and mortality-to-incidence ratio in relation to socioeconomic development. Breast Cancer Res Treat. 2021;186(2):421-32.
5. Chen H, Xu L, Li L, Liu X, Gao J, Bai Y. Inequalities in breast cancer mortality-to-incidence ratios across world regions and their association with health system indicators. BMC Public Health. 2021;21(1):1930.
6. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209-49.
7. Ferrari SLP, Cribari-Neto F. Beta regression for modelling rates and proportions. J Appl Stat. 2004;31(7):799-815.
8. O'Donnell O, van Doorslaer E, Wagstaff A, Lindelow M. Analyzing health equity using household survey data: a guide to techniques and their implementation. Washington, DC: World Bank; 2008.
9. Erreygers G. Correcting the concentration index. J Health Econ. 2009;28(2):504-15.
10. Wagstaff A, van Doorslaer E, Watanabe N. On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. J Econom. 2003;112(1):207-23.
11. Anderson BO, Ilbawi AM, Fidarova E, Weiderpass E, Stevens L, Abdel-Wahab M, et al. The Global Breast Cancer Initiative: a strategic collaboration to strengthen health care for non-communicable diseases. Lancet Oncol. 2021;22(5):578-81.
12. Anderson BO, Shyyan R, Eniu A, Smith RA, Yip CH, Bese NS, et al. Breast cancer in limited-resource countries: an overview of the Breast Health Global Initiative 2005 guidelines. Breast J. 2006;12 Suppl 1:S3-15.
13. Nindrea RD, Armaita, Mardiah A, Ming LC, Syarief I, Putra MSKS, Falisha N, Cahyani RA, Mardhatillah TF, Elsaputri N. Assessing health beliefs and patient delay among breast cancer patients in West Sumatra, Indonesia. MethodsX. 2026;17:104035.
14. Nindrea RD, Novera M, Syahrial S, Avilla NA, Putri FAR. Scoring System for Predicting Breast Cancer Risk Among Women in Regions with Limited Healthcare Infrastructure in Indonesia. Asian Pac J Cancer Prev. 2026;27(4):1459-1467.
15. Foerster M, Anderson BO, McKenzie F, Galukande M, Anele A, Adisa C, et al. Inequities in breast cancer treatment in sub-Saharan Africa: findings from a prospective multi-country observational study. Breast Cancer Res. 2019;21(1):93.
16. Ginsburg O, Bray F, Coleman MP, Vanderpuye V, Eniu A, Kotha SR, et al. The global burden of women's cancers: a grand challenge in global health. Lancet. 2017;389(10071):847-60.
17. Abdel-Wahab M, Zubizarreta E, Polo A, Meghzifene A. Improving quality and access to radiation therapy - an IAEA perspective. Semin Radiat Oncol. 2017;27(2):109-17.
18. Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. Lancet Oncol. 2015;16(10):1153-86.
19. Zubizarreta E, Van Dyk J, Lievens Y. Analysis of global radiotherapy needs and costs by geographic region and income level. Clin Oncol (R Coll Radiol). 2017;29(2):84-92.
20. World Health Organization. Global breast cancer initiative implementation framework: assessing, strengthening and scaling up services for the early detection and management of breast cancer. Geneva: WHO; 2023.
21. Hogan DR, Stevens GA, Hosseinpoor AR, Boerma T. Monitoring universal health coverage within the Sustainable Development Goals: development and baseline data for an index of essential health services. Lancet Glob Health. 2018;6(2):e152-68.
22. Nindrea RD, Aryandono T, Lazuardi L, Ingle RG, Ming LC, Alsaleh NA, Alsharif AA. Dietary fat and calorie consumption in relation to breast cancer risk in a multicenter Indonesian study. Clin Epidemiol Glob Health. 2026;39:102354.